Integrity ★ Service ★ Excellence

Overview of USAF NDE R&D Activities

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Mission and Vision of NDE Branch

VISION

Reliable Nondestructive Quantitative Materials/Damage Characterization Regardless of Scale

MISSION

Lead, discover, develop and deliver NDE material/damage characterization technologies to assure maximum reliability and availability of current and future Air Force Systems

Aging Fleet

Ensuring Weapon System Mission Generation

Key to Safety

Enabling CBM + Prognosis

Future Systems

NDE / NDI

- **Critical element of ASIP and PSIP -- safety inspections!**
- **Used as a Risk Management tool (to lower/achieve acceptable risk)**
- **Attributes of RX's NDE/I Activities to meet USAF needs**

1. Maintain NDI infrastructure for field locations (TOs, training, etc)
2. Engineering developments for short-term needs / rapid response
3. **NDE research**
   - **Capability, Reliability, and Efficiency gains**
   - **Enabler for CBM+ and HVM**
     … must know the condition of the aircraft
   - **Discover methods to evaluate advanced materials**
     … initial and changing states

Talking Points

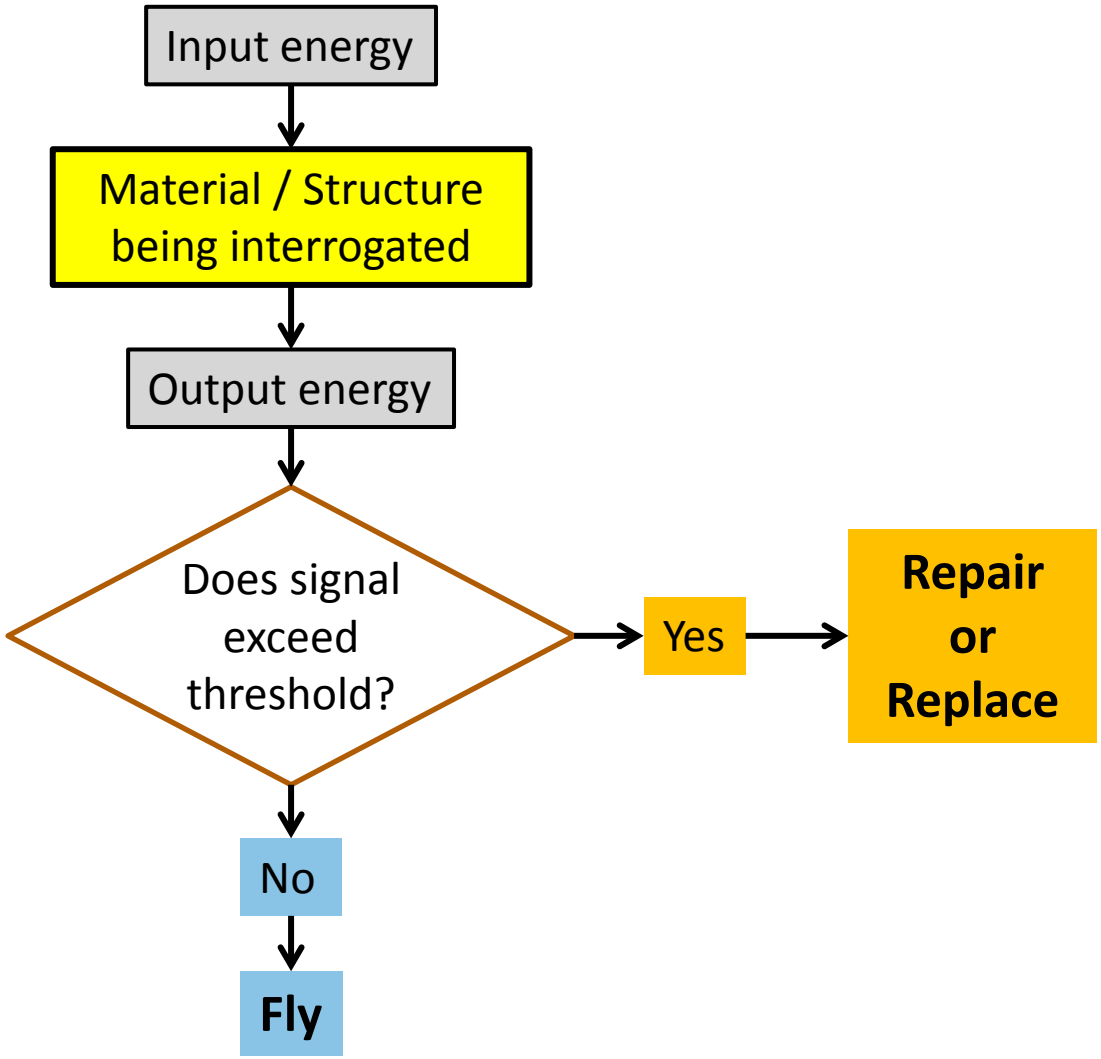
Near-Term

- Improve inspection tools and processes used by the USAF

Far-Term

- Enable paradigm shift ... know condition
- Enable application of advanced materials

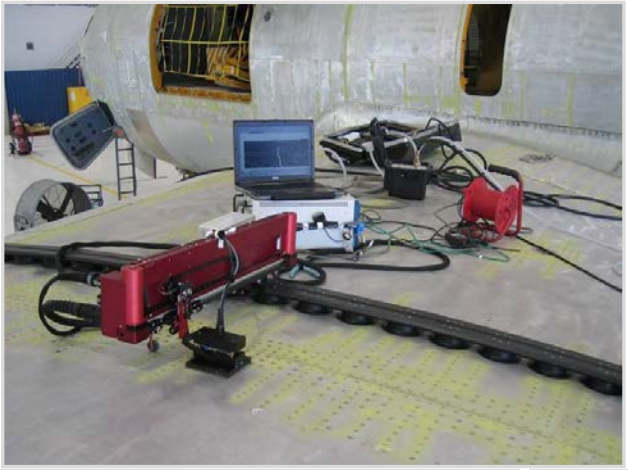
NDE as Traditionally used by USAF



Past RXLP R&D focus was better techniques to detect smaller flaws

- Very Valuable
- Very Successful

Today's Reality



What are we doing?

Better NDI/E

- **Enhance capability … to detect damage**
- **Improve reliability … of detecting damage**
- **Increase efficiency … in inspection processes**

Emphasis Areas

- **Advanced Eddy Current Probes**
- **Magnetoresistive (MR) sensing**
- **Remote Access**
- **Damage Characterization for Turbine Engine Components**
- **Model-Assisted Probability of Detection (MAPOD)**

Conformal Eddy Current Probes Safety of Flight Inspections (SOFI)

Motivation

- Inspection of features (fasteners, edges, radii) can be slow and difficult
- Capability insufficient to ensure safety at currently defined recurring inspection interval

Goal: **More efficient and capable inspection**

Solution

- Build off conformal eddy current probes developed for F-22

Approach

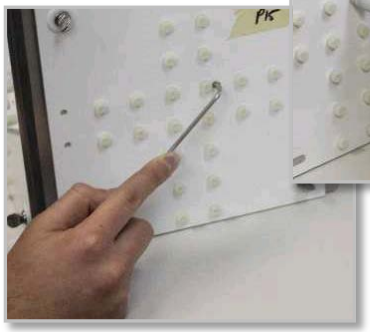
- Validate capability (POD study)
- Field initial kits

Payoff

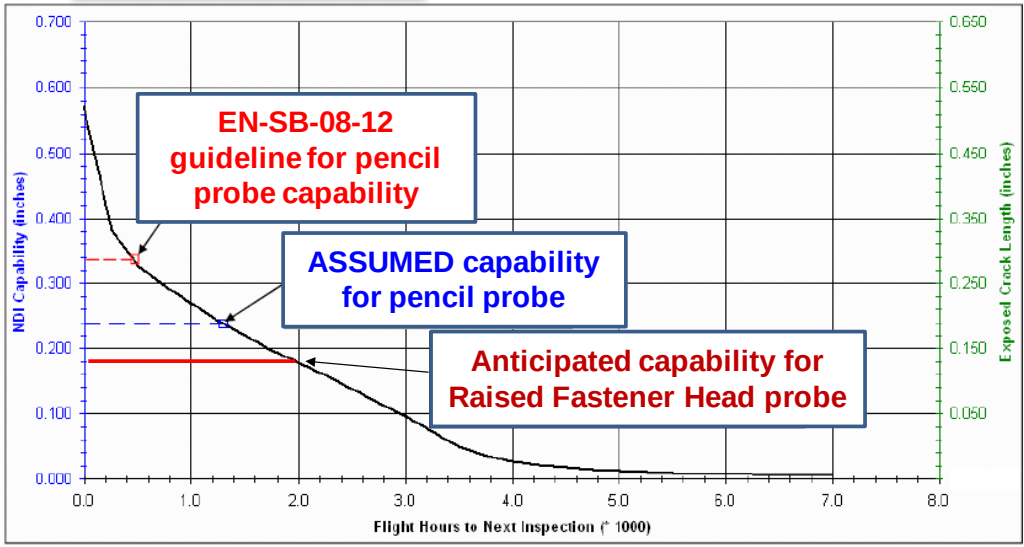
- **Increased inspection interval**
- **Reduced inspection time**

Raised Head Fastener Probe

Pencil Probe



Radius Probe



NDI capability in a tool that is easier to use that minimizes chances for human error

Magnetoresistive (MR) Sensing

Motivation

- Need to inspect internal surfaces of multi-layered structures
- Significant MX burden to gain access
- Low frequency EC from outer surface often inadequate

Goal: **More efficient and capable inspection**

Solution

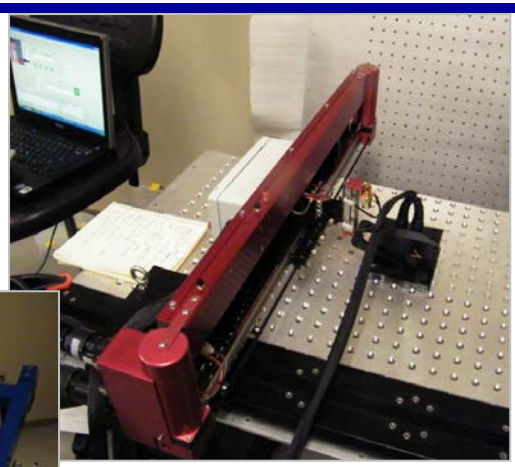
- MR sensing array

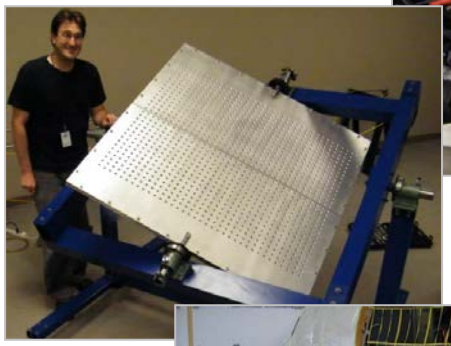
Approach

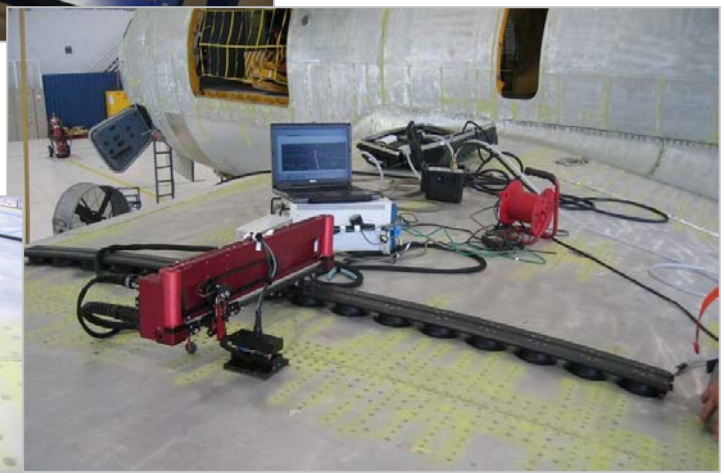
- Mature single-array MR technology
- Develop bi-lateral sensor and analysis software
- Integrate into mobile automated system (MAUS)
- Validate capability (POD study)
- Verify on KC-135 WS 360

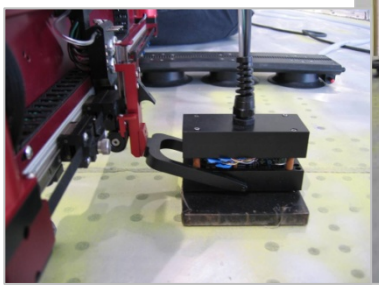
Payoff

- **Reduced MX burden**
- **Easier inspection processes**









Provide better capability integrated into familiar equipment

Remote Access NDE

Motivation

- Limited access often necessitates structural disassembly or inspectors working in constrained space

Goal: **Reliable inspection tools for limited-access areas**

Solution

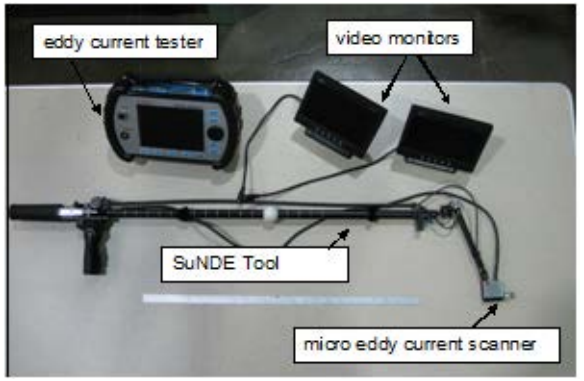
- Rigid manipulation for open spaces
- Flexible manipulation for constrained spaces

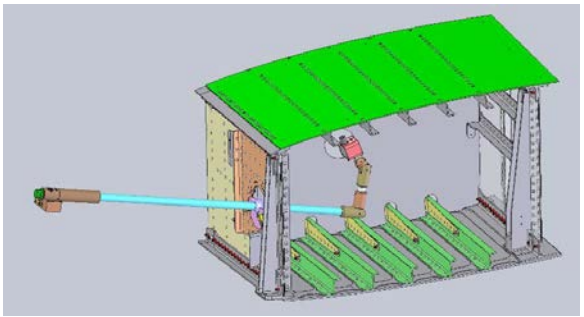
Approach

- Lessons learned from Surgical NDE prototype
- High precision / remote sensor control / adjustable reach
- Integrate SOA sensing (EC, UT, etc)
- Validate inspections capability

Payoff

- **Minimize disassembly / MX burden**
- **Better reliability for inspections of hard to reach areas**





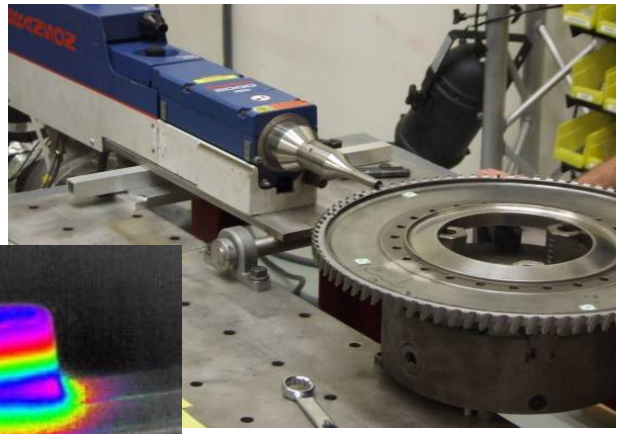
Provide a tool that is easy to use that can verify inspection was accomplished completely

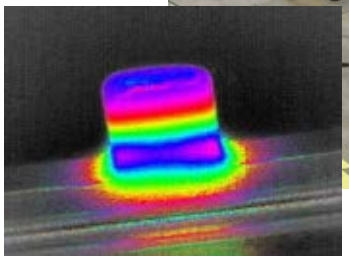
Damage Characterization for Turbine Engines

Motivation

- Eddy current: very good capability, but can be very slow
- FPI: Time consuming and generates hazardous waste

Goal: **Quick and accurate inspection of components**



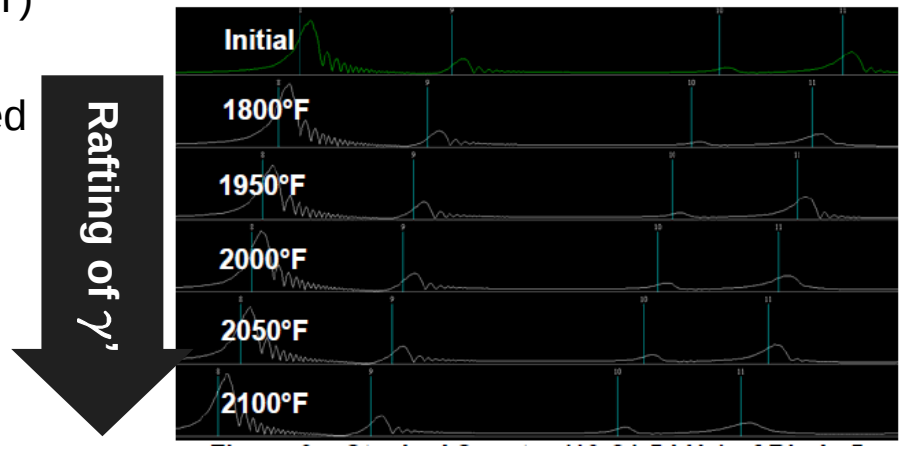


Solution

- Alternative whole-field inspection

Approach

- Sonic IR
- Process Compensated Resonance Testing (PCRT)
- Model-driven design and data interpretation
- Validate inspection capabilities / POD from imaged data



Payoff

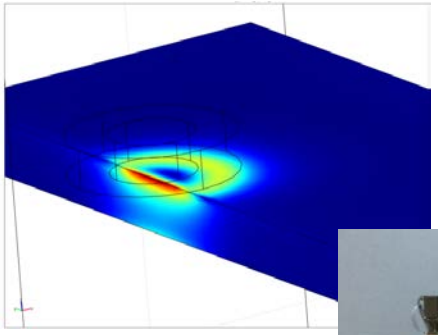
- **Reduce MX burden**
- **Eliminate hazardous waste stream**
- **Extension of component lives**

Reduce MX burden & improve disposition decisions

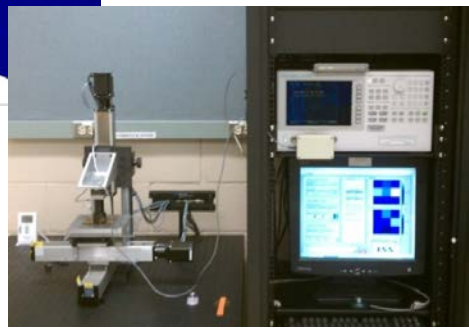
Model-Assisted Probability of Detection

Motivation

- Must assess capability and reliability for NDI methods
- Experimental approaches are costly / time consuming

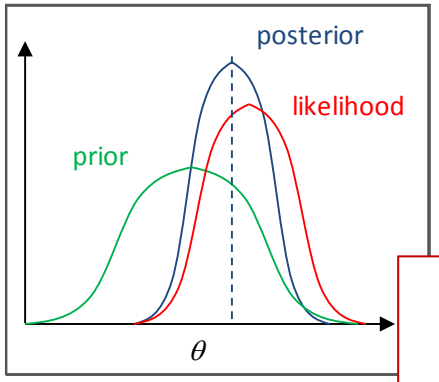


Goal: **more efficient methods to conduct POD assessments**



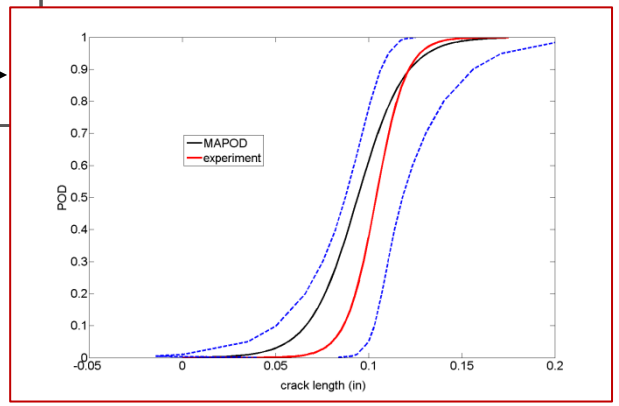
Solution

- M&S to supplement experimental data



Approach

- Multiple levels of models – all have a role
- Incorporate more of the physics into "forward" models
- Targeted experiments to validate
- Account for uncertainty



Payoff

- **Quantify reliability of POD studies**
- **Improved risk assessments**

Reduce experimental burden for POD studies

Talking Points

Near-Term

- Improve inspection tools and processes used by the USAF

Far-Term

- **Enable paradigm shift ... know condition**
- **Enable application of advanced materials**

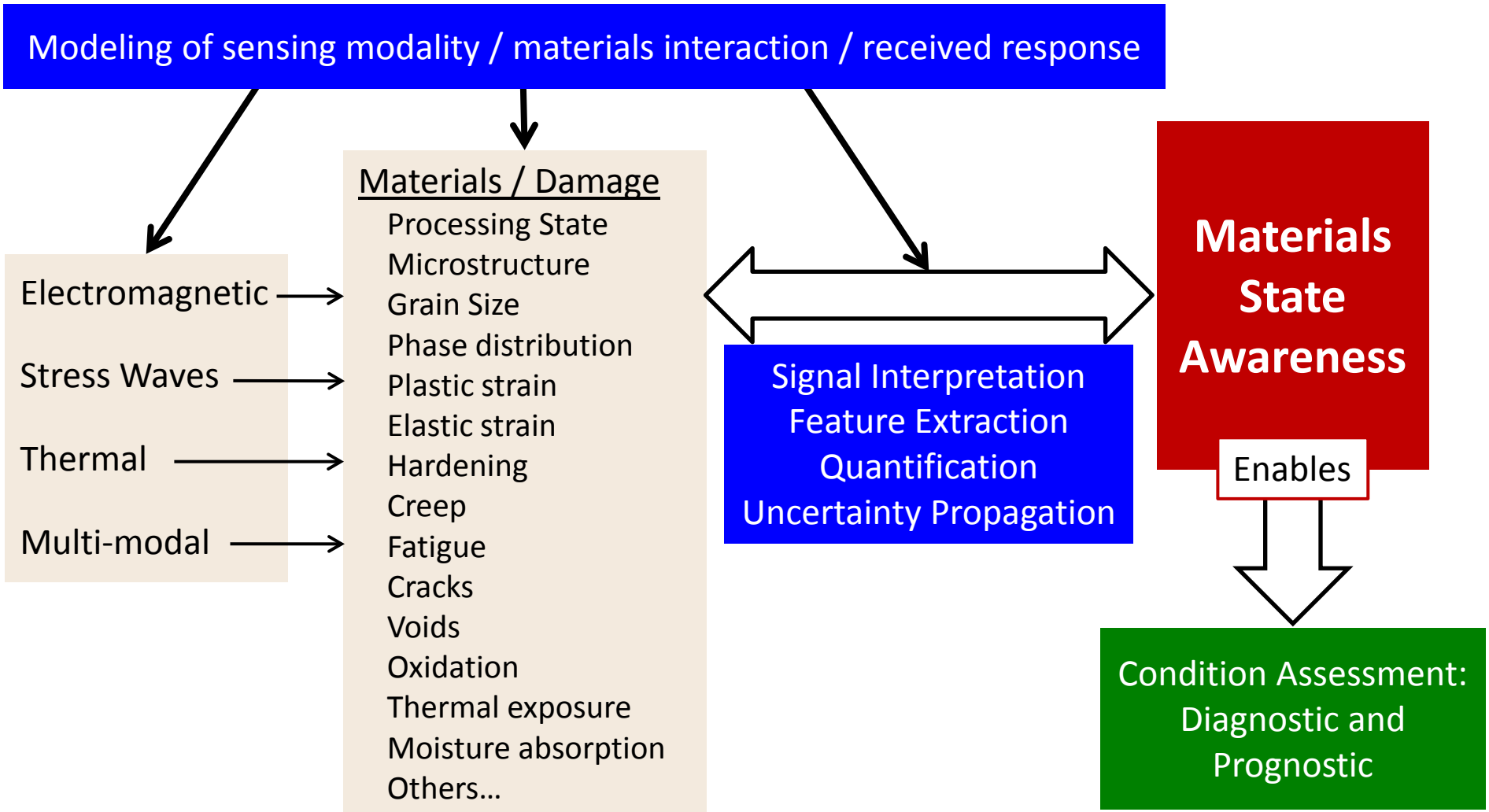
Material State Awareness (MSA)

Reliable Nondestructive Quantitative Materials / Damage Characterization Regardless of Scale

- **Complete characterization!**
  - **Macro scale (i.e. cracks and corrosion)**
    - **Detect … Locate … Size**
  - **Micro scale (e.g. microstructure)**
- **Metals, PMCs, CMCs**
- **Statistical metrics / uncertainty quantification**

MSA is our vision for the future of NDE

NDE Role in CBM+ and HVM … Assess Condition



In-House Research Challenges

Integrated Computational and Experimental Research

- Modeling and simulation vital
- Variability / confounding factors
- Validation

macroscopic service damage characterization

smaller & incipient damage

initial & evolving (micro)structure characterization

processing - microstructure evolution

residual stress

Summary

- **Nose-cone to rudder, cradle to grave, NDE touches entire aircraft**
  - Sustains current capability
  - Enables future capability
- **Model-centric strategy to realize future capability**
  - Assess condition, not just detect
  - All dimensional scales
- **Broad-based impact to improve availability of high performance, capable, and safe USAF systems**
- **New approaches for materials characterization**
  - Materials development/tailored properties validation
  - Processing enhancements via property measurement and feedback

Capability, Reliability, and Efficiency